GPS Equipment and Satellites

Don Hillger and Garry Toth

The **Global Positioning System (GPS)** is an integral part of our modern world. GPS receivers are ubiquitous and relatively inexpensive, but they rely on a complex network of satellites. The first of the GPS satellites was launched in 1978, but the system was not declared fully operational until the mid-1990s. Equipment for GPS includes receivers and display units, both of which are often combined into a handheld GPS unit.

The Transit Satellites and the Beginnings of GPS

Satellite-based navigation began with the **Transit** satellites in the early 1960s. This series consisted of several types of spacecraft designed to test various functions of a satellite navigational system. Early Transit navigation systems used the Doppler effect to determine positions on Earth relative to the satellites. Later Transits tested other satellite navigation techniques.

In total, at least 30 Transits were launched through the mid-1980s. Much of the later Transit technology found its way into the GPS system; in particular, the use of two broadcast frequencies to compensate for delays in the received signals due to atmospheric effects.

Transit-2A satellite (Panama Scott 457A, 1964).

Transit satellites can be found on many stamps or in the margins or selvage of some stamp sheets. A particularly good image of Transit-2A is found on a stamp from Panama (Scott 457A) issued in 1964.

Following the Transit series, two **TIMATION (TIMe navigATION)** satellites were launched to test the use of precise atomic clocks in orbit. Such clocks are a necessary component of GPS systems. However, neither of those satellites is known to be shown on any postal items other than launch covers.

The U.S. GPS System

The U.S. GPS system relies on **NAVigation System using Timing And Ranging (NAVSTAR)** satellites. More than 60 NAVSTAR satellites have been launched to date, and there are currently 24-32 operational satellites in the U.S. GPS / NAVSTAR constellation (including extra satellites in case of failures).

Probable NTS-2 satellite (Comoro Islands, Michel 428, 1978).

GPS satellites carry very precise clocks and send down time signals on at least two frequencies in the 1.1-1.5 GHz range. GPS receiving units can compute their location after receiving the timing signals from four satellites. In fact, three satellites are sufficient to provide a location (one can think of this as a sort of "triangulation" in three dimensions); the fourth satellite allows a much higher degree of precision in the location, as there can be large errors associated with the calculations involving

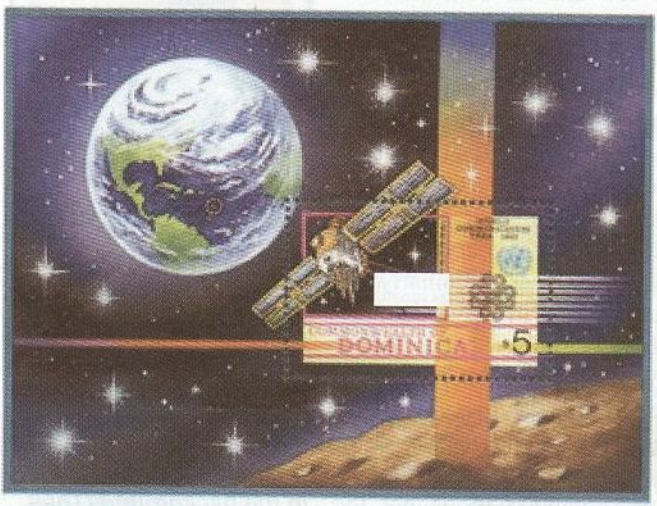
extremely small timing differences when only three satellites are used.

GPS satellites orbit in what is called a Medium Earth Orbit (MEO), at an altitude of 20,200 km, a level between the much lower orbits occupied by most polar-orbiting weather and Earth resources satellites and the much higher orbits of geostationary weather and communications satellites. The GPS satellites occupy six high-inclination orbital planes, with each satellite orbiting Earth twice each day.

NTS-1 satellite (Angola, Scott 1110e, 1999).

GPS/NAVSTAR satellites can be found on several postal items. A close likeness to NTS-2 (Navigation Technology Satellite), an early/prototype version of NAVSTAR, is seen on a stamp issued by Comoro Islands (Michel 428) in 1978. Much later, a stamp issued by Angola (Scott 1110e) in 1999 shows the NTS-1 satellite, but with "NAVSTAR" in the text on the stamp. Both NTS satellites were precursors to the GPS/NAVSTAR spacecraft.

GPS/NAVSTAR satellite (Ciskei, Scott 192 and 194a, 1992).



NAVSTAR satellite (Dominica, Scott 804, 1983).

NAVSTAR-2R satellite (Malagasy, Scott 1416a, 1999).

A first-generation NAVSTAR is seen on a stamp and souvenir sheet issued by Ciskei (Scott 192 and 194a) in 1992, as well as on a souvenir sheet issued by Dominica (Scott 804) in 1983.

One of the later versions, NAVSTAR-2R, is found on a stamp issued by Malagasy (Scott 1416a) in 1999, as part of a sheet of nine stamps showing animals and satellites.

GPS receivers and equipment

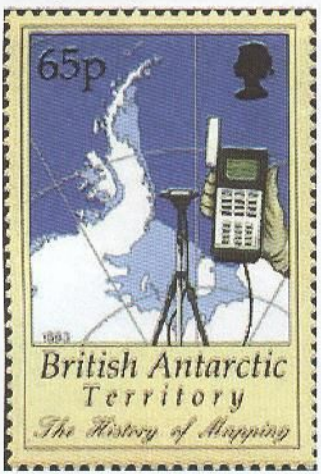
Although GPS was designed and is operated by the Department of Defense to send precise signals for military uses, less-precise signals intended for civilian use are also broadcast. However, the military-grade signals have been available to everyone since 1983, partly as a result of the shooting down of a civilian Korean airliner after it drifted into Russian prohibited airspace.

The major use of GPS is for navigation. Through technological advances, the size of GPS receiving equipment has been greatly reduced over time, while the capabilities have greatly increased. As an example, a hand-held GPS receiver is found in the selvage of a lighthouse stamp issued by Venezuela (Scott 1626j) in 2002. The entire sheet of 10 lighthouse stamps has a navigation theme along the selvage. Also shown in the selvage next to the receiver is a first-generation GPS/NAVSTAR satellite.

GPS receiver and first-generation NAVSTAR satellite on selvage of lighthouse stamp (Venezuela, Scott 1626j, 2002).

The use of GPS has greatly increased the speed and accuracy of surveying and mapping, which can be an arduous task in difficult terrain. A good example of a surveyor using GPS signals to assist with transit readings is found on a stamp issued by Thailand (Scott 1383) in 1991.

GPS-assisted surveying and mapping is a particular boon in the world's most remote areas, where landmarks are nonexistent or few and far between. Two examples of the use of GPS in the Antarctic are found on postal items from the appropriate postal authorities. A stamp issued by the British Antarctic Territory (Scott 257) in 1998 shows a handheld GPS unit, along with a tripod-mounted GPS receiver. Similarly, a stamp issued by Australian Antarctic Territory (Scott L104) in 1997 show a different style of tripod-mounted receiver along with other equipment used for scientific surveying.



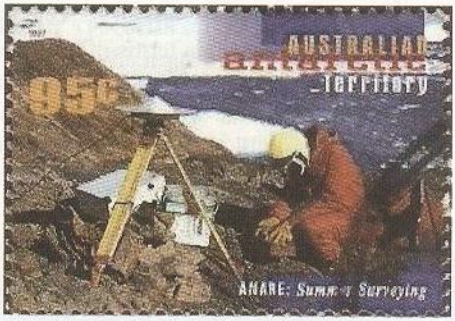
Handheld GPS unit and receiver on tripod used for mapping (British Antarctic Territory, Scott 257, 1998).

GPS-assisted surveying as implied by the waves emanating from the tripod-mounted antenna in the background (Thailand, Scott 1383, 1991).

Although GPS is not the sole source of navigation data

for aircraft, it is becoming increasingly useful to supplement other navigation systems that are not as accurate or as reliable. An example is seen on a stamp issued by Fiji (Scott 781) in 1996, in which a constellation of four navigation satellites assists with aircraft navigation. Similarly, ships at sea can use GPS for precise navigation.

Modern in-car navigation systems are typically accompanied by electronic road maps that continuously update the map with movement of the GPS unit, to present a map centered on the driver's location. The direction of motion is given by the heading calculated by the unit. Such systems can assist drivers with directions and routing. In fact, the well-known in-car On-Star system in North American automobiles can provide GPS-guided navigation for road travel, even without an in-car display.



GPS receiver mounted on a tripod, used for surveying (Australian Antarctic Territory, Scott L104, 1997).

Four GPS satellites and another satellite assisting with airplane navigation (Fiji, Scott 781, 1996).

Similarly, hand-held GPS units for walking or hiking can provide detailed information that is updated continuously, sometimes with detailed topographic maps. However, despite the fact that more than a billion such GPS units are in use, their appearance on postal items is still relatively rare.

Some of the other uses of GPS are for target tracking, reconnaissance, missile and projectile guidance, and search and rescue. GPS satellites also carry nuclear detonation detectors which are designed to act as an early warning system for treaty verification. GPS signals can also be used to measure atmospheric water vapor at high spatial and temporal resolutions, providing information to meteorologists that was not previously available.

GPS Coordinates

GPS coordinates, in terms of latitude and longitude, are now much more common than a decade or two ago when such coordinates meant little to the average person. Any location on Earth can be specified with such coordinates. As an example, a series of five (water and wind) mill stamps issued by South Africa in 2007, one of which is shown (Scott 1375b), contain latitude and longitude coordinates, given in degrees, minutes and seconds, for each of the mills featured.

GPS coordinates (degrees, minutes and seconds) in vertical text to the left of the mill, rotated and magnified (South Africa, Scott 1375b, 2007).

Navigation systems and equipment on cancels

GPS-related cancels can also been found. An Austrian cancel from 1994 shows a constellation of 18 navigation satellites orbiting the earth. The text in the upper-right translates to "Surveying in the upwind," or more appropriate in English might be "Surveying on the upsurge." Austria seemed to like the satellite navigation theme, as it was similarly used on the reverse of a commemorative bi-metal coin issued in 2006.

In addition, a cancel from the World Stamp Expo in 2000 shows a handheld GPS unit; such devices were just starting to become a popular consumer item at that time.

Constellation of 18 navigation satellites (Austrian cancel, 1994).

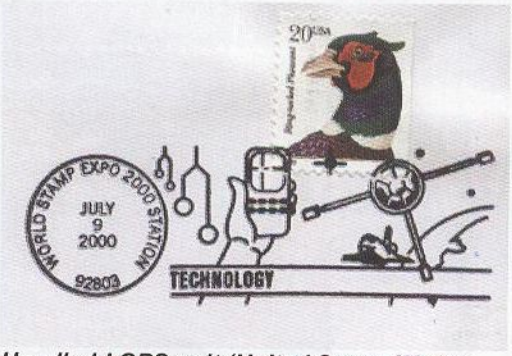
Constellation of 8 European navigation satellites (Austria coin, Krause and Mishler 3135, 2006).

Chances are good that your topic has a checklist!
What do you collect?

Other satellite navigation systems

Other emerging or planned navigation constellations, which go by the generic name of **"global navigation satellite system (GNSS)"** include:

- Russia's **GLONASS (GLObalnaya NAvigationnaya Sputnikovaya Sistema)** / also named **Uragan**.
- Europe's **Galileo** positioning system.
- China's **Compass / Beidou** global / regional navigation system covering Asia and the west Pacific Ocean.
- India's **IRNSS (Indian Regional Navigational Satellite System)** covering India and the northern Indian Ocean.
- Japan's **QZSS (Quasi-Zenith Satellite System)** regional system covering Asia and Oceania.



Handheld GPS unit (United States World Stamp Expo cancel, 2000).

The Russian **GLONASS / Uragan** system, although started in the 1980s, was incomplete when the Soviet Union dissolved in 1991, and suffered decline through the 1990s. The system was given new life by Russia in the 2000s and is now near full capability, being given an increased priority in funding and number of launches.

The other systems already mentioned are still in very early stages of development, some with their first satellites in orbit. Of all of these, however, only the **Galileo** system is known to be shown on postal items.

The European Space Agency (ESA) Galileo constellation was designed as an independent commercial satellite navigation system that would not suffer from possible outages of GPS or GLONASS during times of war or conflict. Plagued by the recent worldwide economic downturn, only two experimental satellites called **GIOVE (Galileo In-Orbit Validation Element)** have been launched. The first operational Galileo satellites were expected to follow in late 2011.

Two levels of Galileo service are expected, both low- and high-accuracy signals, with the former to be free and the latter to be available at extra cost. Another feature of Galileo that is not found on GPS or GLONASS, are Search and Rescue transponders, which up to this point have only been placed on operational weather satellites from several countries.

Galileo constellation satellites are found

A single ESA Galileo satellite in margin/selvage of this Aristotle stamp (Chad, unlisted, 2009).

on at least three stamps. A Galileo satellite is found in the margin or selvage of a stamp released by Chad (unlisted) in 2009, part of a sheet of nine stamps. A St. Thomas and Prince stamp (unlisted) from 2006, part of a souvenir sheet of three stamps, shows at least two Galileo satellites.

Finally, a French stamp (Scott 3500) issued in 2009,

Two ESA Galileo constellation satellites (St. Thomas, unlisted, 2006).

Nine ESA Galileo constellation satellites, 2007 (France, Scott 3500, 2009).

ESA Galileo ground station inauguration, 2007 (French Guiana, cachet on cover, 2009).

part of a souvenir sheet of four stamps, shows nine Galileo satellites.

Launch covers for many of these satellites exist, but are not shown here. However, a cover that is particularly interesting was issued by French Guiana in 2009 for the inauguration of a Galileo ground station, presumably for the command and control functions for the Galileo system.

Additional online information

A checklist of postal items identified as showing GPS satellites and receivers (***rammb.cira.colostate.edu/dev/hillger/GPS.htm***) is available as part of a Website developed by the authors for philatelic items related to many different unmanned satellites (***rammb.cira.colostate.edu/dev/hillger/satellites.htm***). Users of the website are asked to provide missing or additional information or images that they may have related to GPS on postal items. The online information about GPS will be updated whenever new details are provided to the authors.

Previous satellite navigation-related publications

Hillger, D.W., and G. Toth, 2007: "Saving lives with satellites," *Topical Time*, 58(3) (May/June), 41-43.

Hillger, D., and G. Toth, 2009: "Un-manned satellites on postage stamps 34: The Nadezhda series," *Astrophile*, 54(1) (January/April), 92-93. [Reprinted: *Orbit*, (86), 2010 (June), 16-17.]

Biographical notes

The authors have researched and written extensively on the subjects of weather, climate and unmanned satellites on stamps and covers.

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